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SOME QUESTIONS ON THE POPULATION BIOLOGY OF HELMINTHS OF SALMONID FISH OF LAKE AZABACHE (KAMCHATKA)

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Recently, the approach to parasites as components of the biocoenosis /169 has been firmly established. According to this approach, parasites have a major effect on the size of the populations of their hosts, regulating and maintaining it at a level which will ensure the survival of the population of parasites /Kennedi, 1978; Roitman, 1981/. Because of this, the study of the population biology of parasitic animals is important both on a general biological level and as a means of solving the practical questions of decreasing their numbers.

The present work is a study of 1) some widespread helminths of salmonid fish of Lake Azabache and their infestation of invertebrates (intermediate hosts) and fish (final hosts), 2) the structure of the imaginal hemipopulations of parasites and their spatial distribution in the intestines of fish, and 3) the effect of different species on each other during co-parasitism.

MATERIAL AND METHOD

The material was collected in June through September of 1981 and in July and August of 1982. Also, data obtained in 1979 were used. With the method of

incomplete parasitological dissection, six species of fish were investigated: the juvenile and sexually mature malma Salvelinus malma (Walbaum), juvenile coho Oncorhynchus kisutch (Walbaum), juvenile sockeye O. nerka (Walbaum), pond smelts Hypomesus olidus (Pallas), threespine Gasterosteus aculeatus linne and ninespine stickleback Pungitius pungitius (Linne), two species of side-swimmers: juvenile and sexually mature Gammarus lacustris Schellenberg and Pontoporeia affinis Lindstr., sphaeriids and other types of mollusks. Altogether, 639 specimens of fish and 5815 specimens of benthos invertebrates were dissected.

Six species of parasites which are widespread among salmonids were studied. Trematodes Crepidostomum farionis (Muller, 1874), nematodes Cucullanus truttae (Fabricius, 1794), thorny-headed worms Metechinorhynchus salmonis (Muller, 1780) /170 and Neoechinorhynchus rutili (Muller, 1780) live in the intestine of the fish; nematodes Cystidicola farionis Fisher, 1798, live in the swim bladder; and trematodes Phyllodistomum conostomum (Olssen, 1876) live in the urinary canals of the kidneys. In order to study the structure of the imaginal hemipopulations of parasites, at least 30 fish were dissected every month, and the stage of maturity of all of the parasites was noted. Four stages were differentiated in the trematodes: the immature, the sexually mature without eggs, small mature parasites (Cr. farionis - up to 1.5-2 mm long, P. conostomum - up to 2-2.5 mm long), and long mature parasites with eggs (4-5 mm). The following stages were differentiated for nematodes and thorny-headed worms: larvae, maturing males and females (in thorny-headed worms - females with embryonic spheres), and mature males and females. The number of parasites at each stage of maturity was expressed in percentages of the total number of worms of the given species.

INFESTATION OF INVERTEBRATES AND FISH

We found larvae of C. Farionis, 6-8 mm long, in the body cavity of side swimmers P. affinis (1.4% ;index of parasite abundance was 0.016). The young crustaceans (up to 4 mm long) were free of the parasite; the sexually mature were

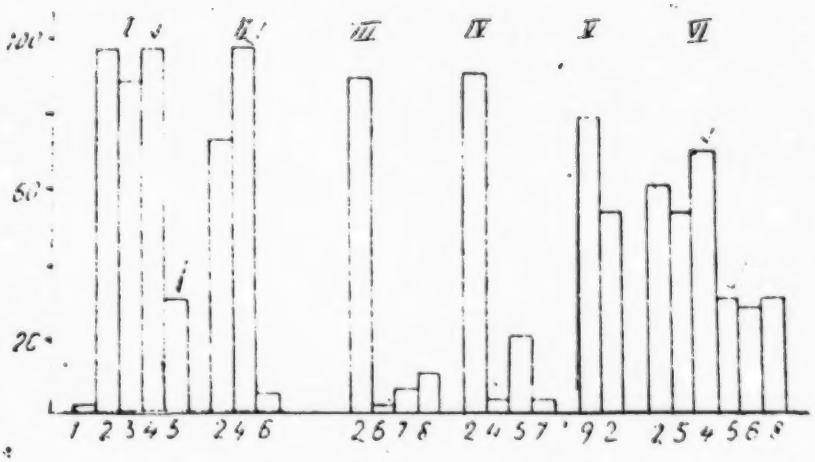


Fig. 1. The infestation by helminths of the invertebrates and fish of Lake Azabache. Along the X-axis - species of animal hosts; along the Y-axis - percentage of infestation I - Cystidicola farionis, II - Metechinorhynchus salmonis, III - Phyllodistonum constomum, IV - Crepidostomum farionis, V - Cucullanus truttae, VI - Neoechinorhynchus rutili; 1 - Pontoporeia affinis, 2 - Salvelinus malma, 3 - Hypomesus olidus, 4 - Oncorhynchus kisutch juv., 5 - O. nerka juv. 6 - Gasterosteus aculeatus, 7 - Sphaeriidae, 8 - Pungitius pungitius, 9 - S. malma juv.

infested to 1.5%, with an index of abundance of 0.017 (Fig. 1). Mature nematodes of C. farionis were found in the swim bladder of malma (from 33.3 to 97.6%; the index of abundance was 34.7-379.2 in fish of different lengths and in different months of the investigation), juvenile coho salmon (13.2-96.6%; 0.3-67.8), juvenile sockeye salmon (30%; 1.9), and pond smelts (6.7-88.0%; 0.7-30.3). Mature females /171 of the parasite in the pond smelts were 10-31 mm long, in juvenile malma - up to 36 mm long, and in sexually mature malma - up to 47.5 mm long. The males of the parasite were 12-26 mm long in pond smelts and juvenile malma and up to 35 mm long in sexually mature malma.

The thorny-headed worms Metechinorhynchus salmonis parasitize in the intestine of malma (16.7-72.0%; 1.0-19.4), juvenile coho salmon (47.4-96.6%; 7.6-14.9), and threespine stickleback (5.6%; 0.06). Mature females of the parasite in juvenile coho salmon were 7-16 mm long, and in malma - up to 19 mm long. Females with embryonic spheres reached 5-9 mm in length, and mature males - 3.5-10 mm.

Sphaeriids were invaded by the larvae of trematodes to 4.6%, including Phyllodistomum conostomum to 2.7% and Crepidostomum farionis - to 1.9%. For comparison, we shall note that pond snails lymnaea auricularia Linne. were infested by the larvae of trematodes to 34.2%, Anisus kamtschaticus (West.) - to 5.9%, Boreoelona contortrix Lindholm - to 5.2%, Cincinna sibirica Midd. - to 1.1%, and C. confusa West. to 0.9%. Sexually mature mollusks Sphaerium corneum L. and S. capiduliferum were infested by P. conostomum to 6.2%; and Cr. farionis to 2.7%. Mature trematodes of both species were found in malma (10-90%; 37.3-450.8 and 2.1-59.2, respectively). Juvenile coho salmon was infested by Cr. farionis to 3.5% (index of abundance - 0.24), and threespine stickleback was invaded by P. conostomum to 1.9% (0.22). Mature specimens of Cr. farionis were 1-3 mm long and those of P. conostomum - up to 5 mm long.

The sexually mature nematodes Cucullanus truttae parasitize in the intestine of juvenile malma (28.6-78.3%; 1.6-6.4) and sexually mature malma (24.0-53.3%; 0.7-4.6). Mature females are 7-16 mm long, males - 5-12 mm, and larvae - 2-6 mm.

Thorny-headed worms Neoechinorhynchus rutili were found in all species of fish in Lake Azabache. Malma is infested by them to 5.3-60.0% (0.1-6.7), juvenile coho salmon - to 10.5-68.9% (0.1-4.7), and sockeye salmon - to 11.0-30.0% (0.3-2.0). The infestation of pond smelts was 4.0-53.3% (0.04-4.4), threespine stickleback - 15.4-27.8% (0.5-2.1), and ninespine stickleback - 30.0% (1.8). In conchostracans, the intermediate hosts of the parasite, this thorny-headed worm has not yet been found. Mature females of juvenile sockeye salmon and ninespine stickleback were 2.5-5.0 mm long; and of pond smelts, threespine stickleback and malma - 4.5-11.5 mm long. Males of juvenile sockeye salmon and ninspine stickleback were 1.8-3.5 mm long, and of other species of fish - up to 5 mm long. Females with embryonic spheres were 3-6 mm long, and the smallest larvae in the fish were 1-1.3 mm long.

Thus, a parasitological study of the fish and invertebrates of Lake Azabache showed (Fig. 1) that the most infested among the latter were the pond snails and lake gammarus, sphaeriids and trumpet snails.

The fish most infested by Cystidicola farionis are malma, pond smelts /172 and juvenile coho salmon, which are the main source of invasion in this body of water. Both species of trematodes invade malma the most, but Cucullanus truttae is found only in this species of fish. Thorny-headed worms are found in greatest numbers in malma and juvenile coho salmon.

STRUCTURE OF THE IMAGINAL HEMIPOPULATIONS OF PARASITES

The study of the imaginal hemipopulations of Cr. farionis and P. conostomum from sexually mature malma (Fig. 2,3) indicates that the infestation of the fish by the larvae and the replenishment of the hemipopulations occurs from June through September, and parasites with an underdeveloped reproductive system are encountered in the fish in all months.

In Cr. farionis, the proportion of immature parasites was greatest in June; in July and August, along with replenishment of the parasite there is maturation. As a result, the relative number of immature individuals decreases noticeably,

and the percentage of sexually mature trematodes without eggs and of mature worms with eggs increases. In August, the mature parasites already comprised more than half of all the trematodes, the number of sexually mature parasites without eggs increased several fold, and the proportion of immature helminths continued to decrease. In September, the bulk of the parasites consisted of mature individuals and sexually mature individuals without eggs (Fig. 2). Thus, a gradual ageing of the imaginal hemipopulation was observed.

Thermal conditions affect the process of maturation of the trematodes. During the summer of 1982, which was marked by low water temperatures (10-14°C), delayed maturation of Cr. farionis was observed, and small individuals predominated among the mature parasites, whereas in July of 1981, the number of small and large mature trematodes was approximately the same, but in August of that year the majority were large parasites (Fig. 2).

In Phyllodistomum constomum the percentage of immature parasites was low in all months, only in August was the replenishment more noticeable (Fig. 3). But the relative number of mature worms was maintained at a high level (averaging approximately 89%). In this case, the replenishment of the hemipopulation apparently proceeds more slowly than in the former species. In 1982, when the rate of replenishment was generally low, the relative number of large mature trematodes was several times lower than in 1981. An increase in the size of the mature parasites was observed in both species of trematodes towards autumn.

The study of the composition of the hemipopulations of the mature nematodes Cystidicola farionis and Cucullanus truttae in malma shows (Fig. 2) that the steady entry of infective larvae into the fish was common to both species, as in the case with trematodes. In C. farionis, the larvae predominated in June and July of 1981; in August, they comprised approximately half of all the parasites, and in /173 September - approximately 40% (Fig. 2). At the same time, the proportion of mature nematodes increased. In 1982, the mature parasites predominated; the

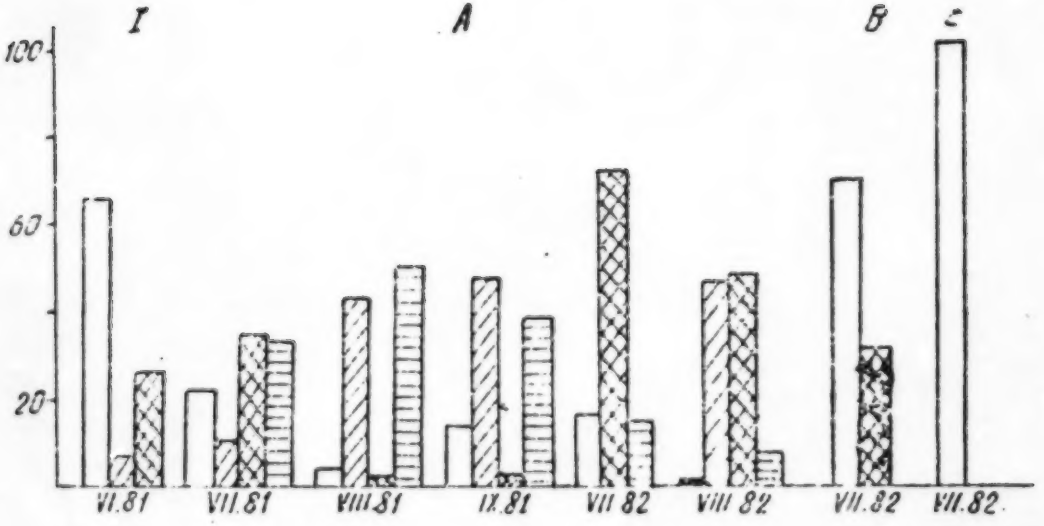
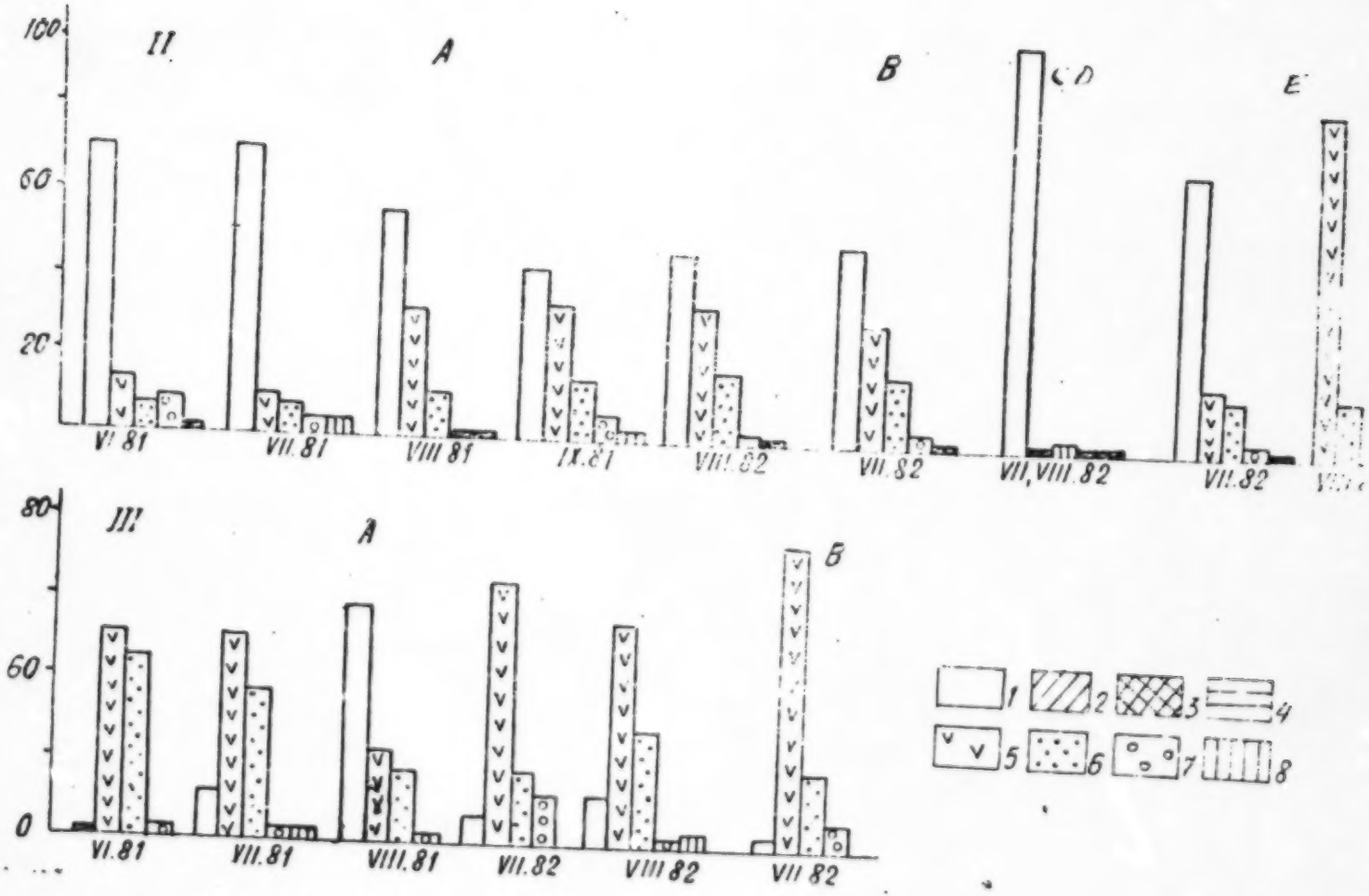


Fig. 2. The structure of imaginal hemipopulations of the helminths of the fish of Lake Azabache. Along the X-axis - time of sample-taking; along the Y-axis - percentage of infestation. I - Crepidostomum farionis, II - Cystidicola farionis, III - Cucullanus truttae; A - Salvelinus malma, B - S. malma juv., C - Oncorhynchus kisutch juv., D - O. nerka juv. E - Hypomesus olidus; 1 - immature parasites, 2 - mature helminths without eggs, 3 - mature small parasites, 4 - mature large parasites, 5 - mature females, 6 - mature males, 7 - maturing females, 8 - maturing males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replenishment of the imaginal hemipopulations was much slower and did not reach the 1981 level.

A completely different picture was observed in C. truttae (Fig. 2), in which the relative numbers of mature parasites (both males and females) decreased in the summer and the proportion of immature individuals increased. An alternation of generations occurred, and the composition of the hemipopulation was rejuvenated. In August of 1981, the larvae comprised up to 60% of all the nematodes. In 1982, this process seems to be moved back by a month: in August, the replenishment was only 11%, as in July of 1981, and mature parasites predominated. In both species the females predominated among the mature nematodes.

Thorny-headed worms Metechinorhynchus salmonis throughout the investigation period were represented primarily by mature worms, with a predominance of females. The percentage of mature parasites increased steadily and was greatest in August and September (96.7-97.2%). In 1981, we found a small number of maturing females with embryonic spheres, and their proportion was always decreasing (Fig. 3). However, in July of 1982, which was a cool year, they comprised almost half of all the parasites, but the relative numbers of mature females was considerably lower than in the same month in 1981. Only in August, when the water temperature was at its maximum, were most of the females mature. Our data on the predominance of mature parasites, particularly females, in the imaginal hemipopulation of Metechinorhynchus salmonis in June through September agree with the results obtained for this same species by Tedla and Fernando (1970). These authors note that in the spring and summer , females with mature embryos predominate in M. salmonis, whereas there are few females with immature Acanthora.

In another species of thorny-headed worms Neoechinorhynchus rutili, in June of 1981, the majority were mature parasites, and in July and August, the majority were maturing worms and larvae. The proportion of larvae gradually increased, and in August, they comprised almost half of all the thorny-headed worms. At the same time, the

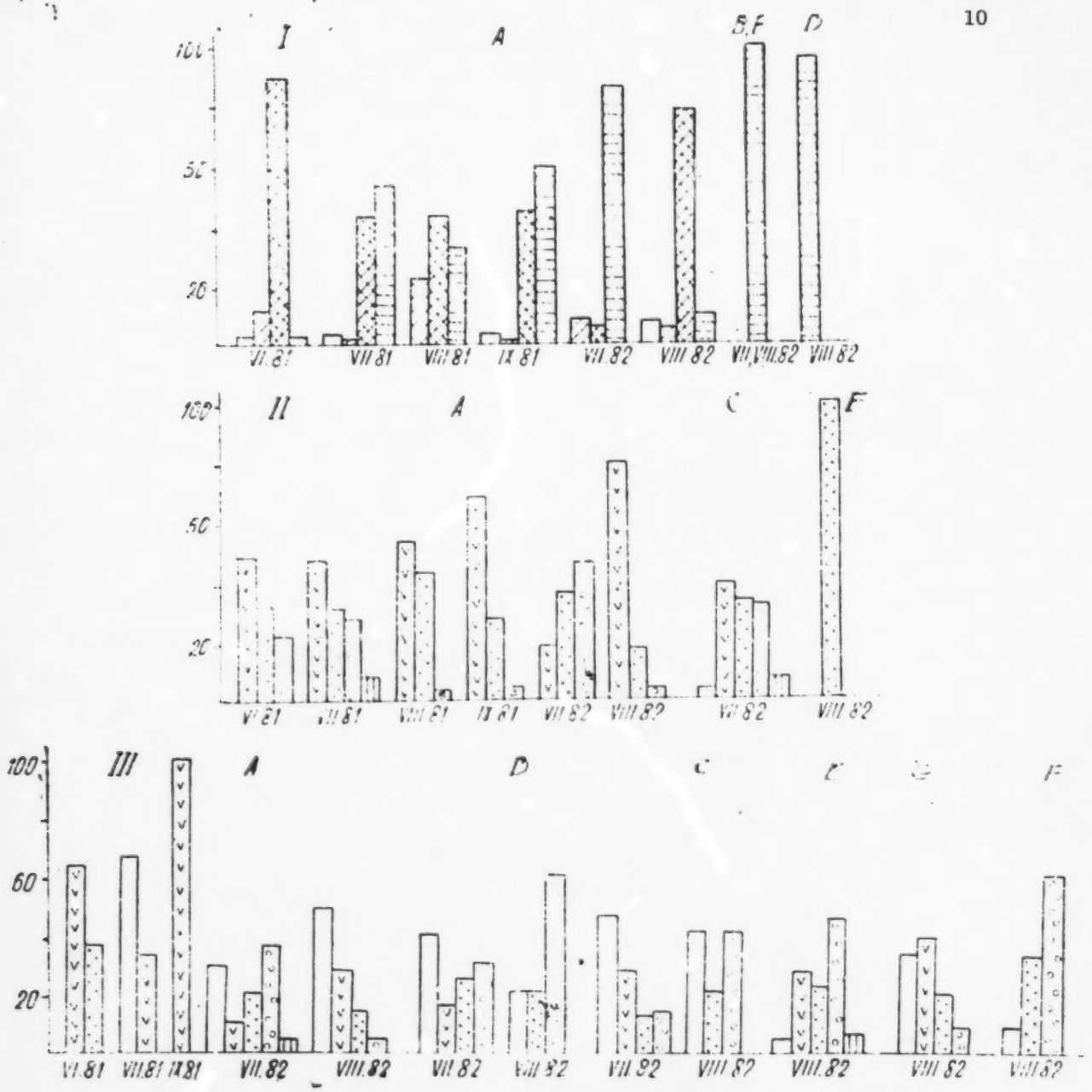

Fig. 3. The structure of imaginal hemipopulations of helminths of fish of Lake Azabache. I - Phyllodistomum conostomum, II - Metechinorhynchus salmonis, III - Neoechinorhynchus rutili; G - Pungitius pungitius, F - Gasterosteus aculeatus. Remaining designations as in Fig. 2.

percentage of mature females increased, and the relative number of females with embryonic spheres decreased (Fig. 3). Hence, the active replenishment of the hemipopulation was accompanied by the maturation of the parasites. The mature females predominated over the males.

Thus, in all of the species studied from malma during the period of investigation it was observed that there was constant replenishment of the hemipopulations with larvae from June through September (less distinct in thorny-headed worms) and maturation of the worms. The maturation process of helminths is affected by the temperature, which can slow it down. Females dominate among the mature /177
parasites. In some species the hemipopulation gradually grows older (Crepidostomum farionis, Cystidicola farionis), in others it is rejuvenated (Cucullanus truttae), and for some species (Phyllodistomum conostomum, Metechinorhynchus monis sal.) it is characteristic for mature parasites to predominate during the entire investigation period.

In juvenile malma, coho salmon and sockeye salmon, primarily the immature parasites of C. farionis and Cr. farionis were encountered (Fig. 2), whereas in the imaginal hemipopulation of Cr. farionis from pond smelts the proportion of mature females increased noticeably (Fig. 2). In trematodes P. conostomum from juvenile malma, threespine and ninespine stickleback, as well as in the thorny-headed worms M. salmonis from juvenile coho salmon, the majority were mature parasites (Fig. 3). In N. rutili from juvenile sockey and coho salmon and threespine stickleback there was a predominance of larvae and immature females.

RATIO OF THE SEXES

Closely related to the structure of the population is the question of the ratio of the sexes, which for parasites is usually determined as the ratio of the number of mature females to the number of mature males (Singhvi and Johnson, 1977; and others). This is evidently associated with the fact that in parasites the females usually predominate (Amin and Burrows, 1977; and others). This was also

observed in our investigation.

The determination of the sex ratio of nematodes and thorny-headed worms showed (see Table) that the number of mature males and females in the /178 imaginal hemipopulations of Cucuilanus truttae and N. rutili from the different species of host fish was approximately the same (see Table). Ony in August of 1979 and in July of 1982 did the females of C. truttae from malma predominate over the males.

In the thorny-headed M. salmonis and nematodes Cystidicola farionis from malma, most of the hemipopulation were females. At the same time, this ratio was close to 1:1 for N. salmonis from juvenile coho salmon, but it could not be determined for the hemipopulations of N. rutili from pond smelts, juvenile coho salmon and juvenile sockeye salmon because of the predominance of larvae.

The frequent predominance of females over males in a population is associated with the favourable conditions of its existence (Ivanov, 1961). In addition, O.N. Bauer and N.P. Nikol'skaya (1957) noted that for M. Salmonis, in most case, the males die soon after copulation, i.e. they have a shorter life cycle than the females. The same was also noted for other species of thorny-headed worms (Burlingame and Chandler, 1941; Awachie, 1966; Amin, 1975; Amin and Burrows, 1977). Data obtained under experimental conditions (Yasuraoka et al., 1960) and under natural conditions (Singhvi and Johnson, 1977) indicate that the males of parasitic nematodes are often eliminated before the females, and their role is reduced only to participation in fertilization. The females, initiating the next generation, are distinguished by genetic longevity. This, in our view, explains the predominance of females in the imaginal hemipopulations of Cystidicola farionis and Metechinorhynchus salmonis.

Along with the study of the structure of the hemipopulations of mature parasites and their ratios between the sexes, we analyzed the nature of the distribution of the parasites in the fish-host population. In all cases the dispersion exceeded by many times the average number of parasites to one host (index of helminth

Table

Ratio of sexes in the helminths of the fish of Lake Azabache

Parasite species	Fish species	Sample number	Number of parasites		Sex ratio*	χ^2
			females	males		
Metechinorhynchus salmonis	Sexually mature malma	1	1300	700	1,86	153,73
	»	2	692	466	1,48	44,10
	»	3	516	330	1,56	40,89
	»	4	49	39	1,26	1,14
	»	5	238	92	2,59	64,59
	»	6	253	141	1,79	31,81
	»	7	342	72	4,75	176,09
	Juvenile coho salmon	8	166	142	1,17	1,87
	»	9	23	27	0,85	0,32
Neoechinorhynchus rutili	Sexually mature malma	10	237	206	1,15	2,17
	»	11	61	29	2,10	11,37
	»	12	70	40	1,75	8,18
	Pond smelts	13	71	56	1,27	1,77
	Juvenile coho salmon	14	37	17	2,18	10,59
Cystidicola farionis	Sexually mature malma	15	1465	1183	1,24	30,03
	»	16	303	175	1,73	34,28
	»	17	1441	922	1,56	113,99
	»	18	814	699	1,16	17,48
	»	19	4352	1953	2,23	912,80
	»	20	418	159	2,63	90,96
	»	21	995	630	1,58	81,98
	»	22	776	403	1,93	118,00
	Juvenile malma	23	98	53	1,85	13,41
	Pond smelts	24	239	198	1,21	3,85
Cucullanus truttae	Sexually mature malma	25	40	25	1,60	3,46
	»	26	134	75	1,79	16,67
	»	27	53	46	1,15	0,49
	»	28	131	97	1,35	5,07
	»	29	37	27	1,37	1,56
	»	30	82	42	1,95	12,90
	Juvenile malma	31	67	16	4,19	31,34

*Determined by means of the criterion of correlation

abundance), i.e. the distribution of the parasites in the populations of their hosts was greatly overdispersed.

SPATIAL DISTRIBUTION OF TREMATODES IN THE INTESTINE OF MALMA

Further studies showed that the trematodes Crepidostomum farionis at different stages of maturity are distributed differently in the digestive tract of malma. The bulk of the immature parasites were found in the pyloric section of the intestine in all months of the investigation (78.3-94.6%). In June, they were found in the gall bladder (2.8%). Here, a negligible number of parasites were found with a partially or completely formed reproductive system. In other sections of the digestive system, a small number of immature parasites were found (4.8-6.3%).

Juvenile trematodes with a formed reproductive system without eggs /180
were distributed differently in different months (Fig. 4). In June, they predominated in the second half of the posterior section of the intestine, in August and September- in the pyloric section, and in July, they were distributed approximately uniformly in all sections. The distribution of the parasites in the intestine is determined, on the one hand, by the replenishment of the imaginal hemipolulation, and one the other hand, by the maturation of parasites and the dying off of old mature helminths.

Mature parasites with eggs were mainly found in the posterior intestine; however, in September the percentage of mature trematodes in the pyloric section was higher (Fig. 4). In malma, mature trematodes of Cr. farionis of different sizes were found; therefore, we studied the distribution of the large mature parasites (up to 4 mm) and the small mature parasites (up to 1.5-2.0 mm) separately. It was found that the /181
large parasites were localized almost exclusively in the second half of the posterior intestine, and only 2 specimens were found in the pyloric section. At the same time, small mature worms were found in all sections of the intestine. In July, their proportion in the pyloric section was 30% of the entire number of

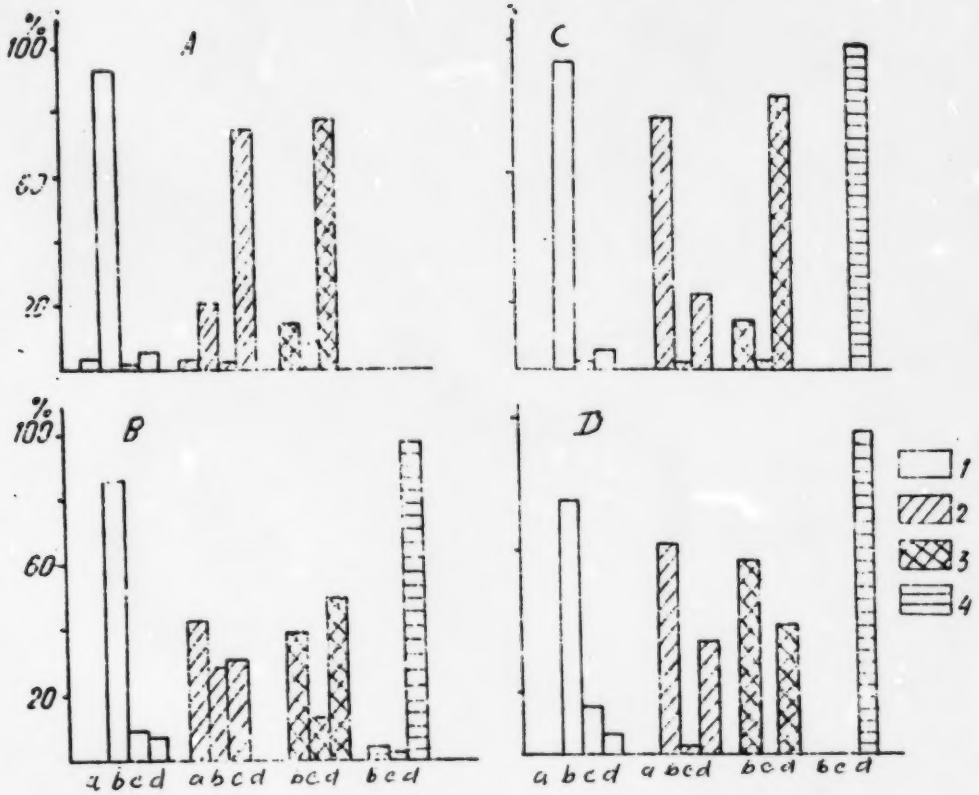

Fig. 4. Spatial distribution of Crepidostomum farionis in the in the intestine of Salvelinus malma. Along the X-axis - sections of the digestive tract; along the Y-axis - percentage of infestation. A - June, B - July, C - August, D - September; a - gall bladder, b - pyloric section, c - first half of the posterior section of the intestine, d - second half of the posterior section of the intestine; 1-4 - designations same as in Fig. 2

these trematodes, and in September it reached 59.9%. During the three summer months the small mature parasites predominated in the posterior intestine.

Thus, according to our data, immature trematodes were localized primarily in the pyloric section, or near it, and in the gall bladder of malma. Sexually mature worms without eggs were encountered in all sections of the intestine. Small mature parasites with eggs were mainly found throughout the entire length of the posterior intestine, but large mature trematodes parasitized almost exclusively in the second half of the posterior intestine. Because of these peculiarities in the distribution of Crepidostomum farionis in the intestine of malma, it can be assumed that the trematodes migrate to the end of the posterior section of the intestine

as they mature. Similar migration was observed for the thorny-headed worms Metechinorhynchus salmonis and Echinorhynchus truttae by O.N. Bauer and N.P. Nikol'skaya (1957), J. Awachie (1966), and O.M. Amin and J.M. Burrows (1977).

It is interesting to note that in the pyloric section of the intestine during all of the summer months of 1981 approximately the same number of trematodes (733-773 specimens) parasitized. This was ensured, on the one hand, by constant replenishment through immature worms and, on the other hand, by the migration of young mature parasites to the posterior section of the intestine. These processes roughly equalized each other. However, in September replenishment began to dominate, and at the same time the total number of nematodes and the number of immature parasites increased.

The study of the spatial distribution of the thorny-headed worms M. salmonis in the intestine of malma showed that in June the parasites were found in the first third of the posterior section of the intestine, not far from the pyloric section. In July, the worms were encountered both in the posterior intestine and in the pyloric section, with 37% of the young immature females with embryonic spheres being found in the latter. Mature females and males predominated in the posterior section of the intestine, and the pyloric section had 16% of the mature females and 34% of the males. In August and September, individual specimens of thorny-headed worms were found in the pyloric part, and the bulk of the parasites were localized in the posterior part of the intestine, where darkened dead mature females were also found (3.3% of all females). We found only one such specimen in the pyloric section of the intestine.

EFFECT OF INTESTINAL PARASITES ON ONE ANOTHER DURING CO-PARISITISM 182

Both trematodes Crepidostomum farionis and thorny-headed worms Metechinorhynchus salmonis parasitize in the intestine of malma, with individuals of both species apparently migrating to the end of this section as they mature. Because of the same localization and the nature of the migration of these species,

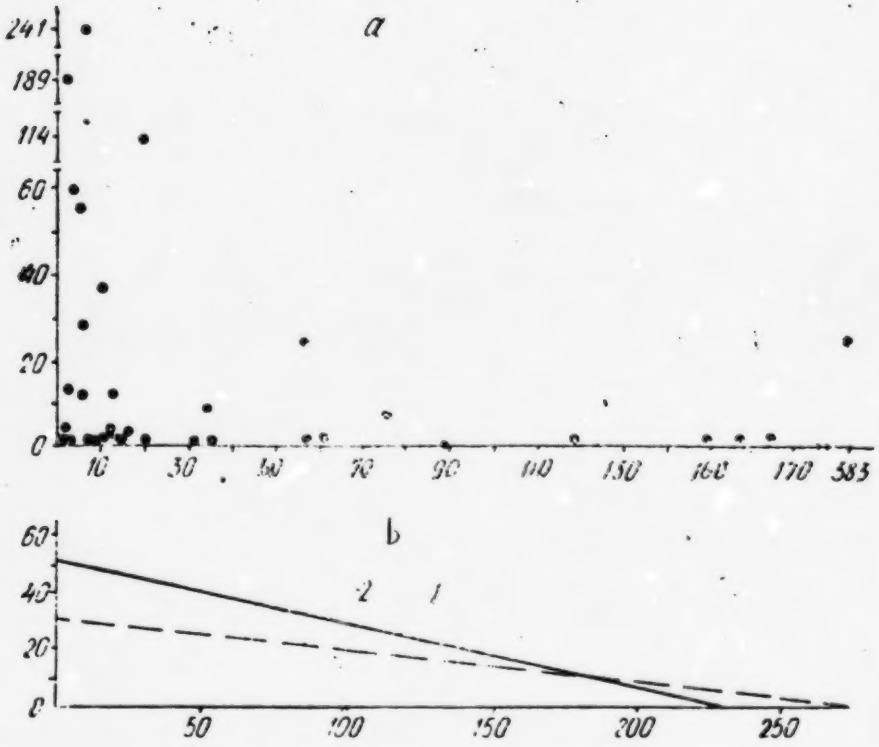

Fig. 5. Effect of intestinal helminths Metechinorhynchus salmonis and Crepidostomum farionis on each other. a - relationship between the numbers of M. salmonis and Cr. farionis; b - theoretical lines of regression (1) x on y and (2) y on x. Along the Y-axis - number of Cr. farionis; along the Y-axis - number of M. salmonis

we assumed that they can somehow affect each other. It was found that in most cases one of these species is encountered in malma. In the case of co-parasitism, when a fish is strongly infested by one parasite species, it is generally weakly infested by the other (Fig. 5a). Cases of weak invasion by both species were also observed. Thus, one can speak of a negative interaction between these species of intestinal helminths. Our theoretical lines of regression for these species of parasites (Fig. 5b) intersect each other at a small angle, indicating a certain /183
correlation between properties, i.e. between these species of intestinal malma helminths.

CONCLUSION

The role of parasites as causative agents of fish diseases has increased considerably in connection with the development of aquaculture and intensive fish breeding,/ particularly of salmonids. Consequently, a new and more modern approach to the study of helminths is required. The study of the population biology of parasites serves as the basis for forecasting the helmithological situation in a body of water and makes it possible to develop modern methods of combatting the parasites.

The data obtained by us on the infestation of the invertebrates and fish of Lake Azabache by helminths made it possible to ascertain both the general parasitological situation and certain characteristics of the population biology of the parasites. The most infested among the invertebrates were the pond snails, lake gammarus, sphaeriids and trumpet snails. The infestation of the remaining species was much less. The most heavily infested were the malma, juvenile coho salmon and pond smelts.

All of the studied species of helminths from malma are characterized by certain common features: the constant replenishment of hemipopulations with larvae in the period from June through September (only in the thorny-headed worms M. salmonis was replenishment less distinct), the maturation of the parasites, and the predominance of females among the mature worms. The process of helminth maturation is affected by the water temperature: in colder years, parasite growth and development slow down.

Three groups of parasites can be differentiated, based on whether mature parasites or larvae dominate in the imaginal hemipopulations of the worms. For Phyllodistomum conostomum and M. salmonis, mature individuals characteristically predominate during the entire investigation period. In Cucullanus truttae the composition of the hemipopulation is rejuvenated in the course of the summer. For Crepidostomum farionis and Cystidicola farionis one can notice a gradual "maturation" of the composition of the hemipopulation. Mainly immature parasites are encountered in the juveniles of the different species of salmonid fish

(sockeye, coho and malma), and only P. conostomum and M. salmonis are represented primarily by mature individuals in the juveniles.

The sex ratio of C. farionis and M. salmonis from malma is significantly different from 1:1. The females predominate over the males, which is apparently associated with the shorter life cycle of the males. Significant differences in the ratio of males to females was not found in other species of parasites from the different hosts. In all cases studied by us the distribution of parasites in fish-host populations was found to be overly dispersed.

The analysis of cases of the co-parasitism of Cr. farionis and M. salmonis in the intestine of malma indicates a definite correlation between these species of intestinal helminths.

REFERENCES

1. Bauer, O.N. and Nikol'skaya, N.P. The dynamics of the parasite fauna of Lagoda whitefish and its epizootological importance. In: Parasites and fish diseases. Moscow/Leningrad, 1957, p. 227-242. (Izv. VNIORKh; Vol. 42).

2. Ivanov, V.G. On the sex ratio in the progeny of animals. Uch. zap. Kabardino-Balkar. gos. un-ta, 1961, No. 12, p. 187-209.

3. Kennedi, K. Ecological parasitology. Moscow: Mir, 1978, 230 p.

4. Roitman, V.A. The population biology of the helminths of freshwater biocoenoses. In: The population and biocoenotic aspects of the study of helminths. Moscow: VINITI, 1981, p. 43-88. (Zooparasitology, Vol. 7).

Awachie J. B. E. The development and life history of Echinorhynchus truttae Schrank, 1788 (Acanthocephala). — J. Helminthol., 1966, vol. 40, p. 11—32.

Burlingame P. L., Chandler A. C. Host-parasite. relations of Moniliformis dubius (Acanthocephala) in albino rats and the environ mental nature of resistance to single and superimposed infections with this parasite. — Amer. J. Hyg., 1941, vol. 33, p. 1—21.

Singhvi A., Johnson S. The female to male ratio (FMR) in dominant Nematode Populations in the house rat Rattus rattus. — J. Parasitol., 1977, vol. 63, N 5, p. 858—860.

Tedla S., Fernando C. H. Some remarks on the ecology of Echinorhynchus salmonis Muller, 1784. — Can. J. Zool., 1970, vol. 48, p. 317—321.

Yasuraoka K., Hosaka Y., Ogawa K. Survival of Ancylostoma duodenale in vitro. — Jap. J. Med. Sci. and Biol., 1960, vol. 13, p. 207—212.